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THE CHILEAN ARTISANAL STONE CRAB (*HOMALASPIS PLANA*) FISHERY: CATCH TRENDS IN OPEN ACCESS ZONES AND THE EFFECT OF MANAGEMENT AREAS IN CENTRAL CHILE

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ABSTRACT The Stone crab *Homalaspis plana* supports an important artisanal fishery along the coast of Chile. The objectives of this study were to analyze the trends in crab catches and CPUE between 1991 and 1994 in open access fishing areas of Central Chile and to compare the size and sex composition of the catches for two alternative fishing gears. We explored three different CPUEs, because abundance indicators have not been used before for this fishery. In addition, we compared the CPUE, the crab size distribution, and the sex ratio between open access fishing grounds and Management and Exploitation Areas (private grounds). Stone crab catches decreased between 1991 and 1994 in open access areas. The Stone crab is caught with crab pots and by divers, and no differences in mean crab size were found between fishing gears in El Quisco. The proportion of males caught in crab pots is higher than that caught by divers, and the proportion of ovigerous females was lower in crab pots. The CPUE (catch per trip) also decreased between 1991 and 1994 in open access fishing grounds. We analyzed alternative CPUEs that could be used for crab as well as for other benthic species. We show that the CPUEHours (catch per hour) is affected by the number of species caught, which suggests the importance of taking this factor into account. The CPUETarget (catch per hour corrected by the number of target species) is not affected by the number of species caught (target and/or bycatch) because this estimator considers the time allocation for the main species collected. The latter may be a more appropriate indicator. No differences in CPUE between open access grounds and Management and Exploitation Areas (private grounds) were observed. The size distribution of crabs in open access fishing grounds and in Management and Exploitation Areas was not significantly different; females predominated in both areas (>90%). Previous studies conducted in Management and Exploitation Areas focused on sessile or sedentary species and clearly showed the effect of human activity (removal) on the abundance and size of exploited species, compared with open access zones. The lack of differences in CPUE, crab size, and proportion of sexes between open access zones and Management and Exploitation Areas suggests that mobile species may offer a new challenge to the management tools recently implemented by the Chilean Fisheries Administration.

KEY WORDS: *Homalaspis plana*, crab, fishery, artisanal, Chile

INTRODUCTION

The Stone crab *Homalaspis plana* (Milne-Edwards, 1934) is distributed from Guayaquil (Ecuador) to the Magallanes Strait and Isla Juan Fernández, Chile (Garth 1957), between the intertidal zone and 272 m (Henriquez and Bahamonde 1976). This crab species supports an important artisanal fishery along the coast of Chile. The fishery is open all year without any limitation in total catches; the only regulations are size limit (>120 mm carapace width) and ovigerous females (Bustamante and Castilla 1987). The current status of the Chilean Stone crab population is unknown, because of the lack of systematic catch statistics. Furthermore, the proportions of ovigerous females and undersize crabs caught are also unknown, because regulations are not properly enforced.

The major gaps in understanding the multispecies artisanal fisheries in Chile are the extreme interest for locos (*Concholepas concholepas*) and the lack of population abundance indicators. The simultaneous catch of several invertebrate species in each fishing trip presents difficulties for the estimate and use of abundance indicators. Besides, information on catch and effort is rarely available for most of the species targeted by the artisanal fishery. One of the few exceptions is Caleta El Quisco (33°23′S, 71°42′W), located in Central Chile, where catch and effort data for the main species exploited started to be collected in 1991, as a new Management and Exploitation Area (MEA) was created. Most of the catch statistics come from open access fishing grounds, because the MEA is closed to the fishery. Since 1991, the MEA was opened only to the loco fishery during the ban lifting, and crabs were first and only harvested in 1995 during a limited time (1 day).

This work is the first approach to analyze the artisanal, Stone crab fishery in Chile. The study was conducted in open access and closed fishing areas in Central Chile, and the objectives were as follows:

(1) to examine the trend in catches and CPUE at the local scale (Caleta El Quisco) between 1991 and 1994. We conducted an exploratory analysis in order to obtain an indicator of crab abundance for the multispecies, artisanal fishery. We think that the CPUE indicators explored here are also of importance for their potential use for other benthic resources. We also think that the analysis of catch data at a local scale may have implications on a larger scale, because the same fishing gear is used along the coast of Chile.
(2) to compare the catch composition (crab size and sex) between two fishing gears (crab pots and divers). This analysis is of interest to assess the effect of each fishing gear on sublegal—size individuals and ovigerous females.
(3) to study the effect of the MEA on the size structure and sex ratio of the Stone crab population. This result is relevant from the perspective of the new management tools recently implemented in Chile. The use of the MEA is a novel, alternative management strategy still under experimentation (Payne and Castilla 1994, Castilla et al. in press). The implementation of the MEAs was based on studies conducted in a marine reserve in Central Chile on sessile and

sedentary species (Castilla and Durán 1985, Durán et al. 1987, Durán and Castilla 1989, Castilla and Bustamante 1989, Castilla 1990, Oliva and Castilla 1990, Oliva and Castilla 1992). However, some of the benthic species targeted by the MEA are highly mobile, among them our study species, the Stone crab.

MATERIALS AND METHODS

Study Site

Our study site is located in Caleta El Quisco, Central Chile (Fig. 1). In Chile, fishermen are organized in unions within Caletas. The El Quisco Union is very well organized and took legal possession of an MEA in 1993 (for details about MEAs, see Payne and Castilla 1994, Castilla and Pino 1996, Castilla et al. in press). However, the union had totally banned (unilaterally) diving activities on a coastal area of 57 ha of sea bottom (3 ha intertidal, 54 ha subtidal) 2 years before (1991). Since then, this area has not been exploited for most benthic resources, except for three extractions of locos during the ban lifting for this species (Payne and Castilla 1994, Castilla et al. in press).

Open access fishing grounds exploited by fishermen of El Quisco are located up to 60 min sailing time north or south from the landing harbor and the El Quisco MEA (EQ; Fig. 1, Table 1). The southern fishing grounds are located near another MEA, assigned to the Fishermen Union of Las Cruces in 1993 (LC, Fig. 1). The MEA of Algarrobo is located toward the north. (A, Fig. 1). Fishermen of Las Cruces do not comply with the fishing restrictions for the MEA as in El Quisco and Algarrobo.

Data Set

Catch data for all of the species landed in El Quisco have been recorded since 1991 by the Fishermen Union. Catch data are reported by species (in numbers and/or weight) per trip; for the Stone crab, catches are reported in numbers. We investigated the fishing trips in which crab was the only or among the most important species caught. The information about other species caught is not presented here but was used to estimate CPUE (see section c). Effort data consisted of total time spent at sea (diving time was not available in the data set). The fishing grounds visited were also recorded. Crab pots were not included in this analysis because this fishing gear has recently been introduced.

CPUE Estimates

One of the main problems faced by the managers of the artisanal fishery in Chile is the difficulty in estimating abundance indicators. On the basis of the data available in El Quisco, we explored several crab abundance indicators that could also be applied to other species targeted by the artisanal fishery. This analysis was conducted to assess the value of different indicators of crab abundance.

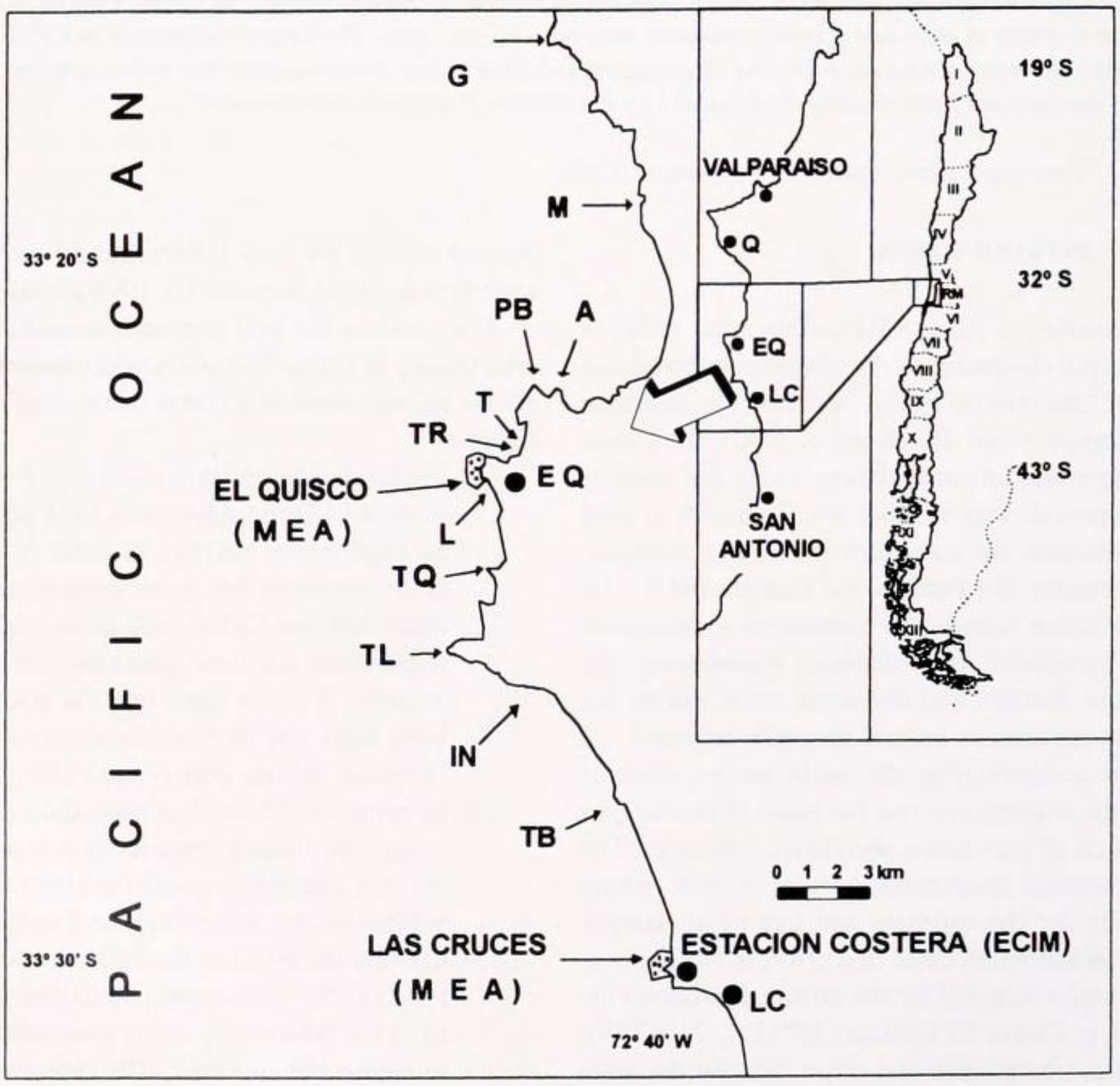

Figure 1. Map showing the regions for which catches are reported and fishing grounds for the study area in Central Chile. The codes used for fishing grounds indicate: G (El Gallo), M (Mirasol), A (Algarrobo), PB (Peña Blanca), T (Los Toros), TR (Toribio), EQ (El Quisco, landing location), L (Los Lobos), TQ (Tablaque), TL (Punta Tralca), IN (Isla Negra), and TB (El Tabo). Shaded zones indicate MEAs (El Quisco and Las Cruces). Dots indicate coastal towns and the Marine Reserve of Las Cruces. Q, Caleta Quintay MEA.

TABLE 1.

Most common fishing grounds used by fishermen of El Quisco (explored more than six times) between 1991 and 1994.

Fishing Grounds			1991		1992		1993		1994	
Location	S. Time	Weather	% Trips	CPUE	% Trips	CPUE	% Trips	CPUE	% Trips	CPUE
Gallo	60 N	7	0.8		10.1	192.0	0.7		5.6	235.0
Mirasol	50 N	20					8.7	91.7	12.7	99.7
Peña Blanca	15 N	10	4.3	102.5	4.2					
Los Toros	10 N	20	5.4	94.4	7.4	127.5	0.7		1.4	
Toribio	10 N	19	8.2	98.0	10.2	115.5	5.3	108.7	18.3	56.0
El Quisco	0	no data	7.8	89.7	9.1	76.8	10.0	86.0	8.4	68.0
Lobos	20 S	21	10.1	82.7	11.6	102.8	10.7	113.0	8.4	50.1
Tablaque	30 S	20	3.1	101.5	4.9	116.1	8.7	121.5	11.3	74.4
Punta Tralca	40 S	19	16.7	121.5	12.9	153.6	16.7	111.7	23.9	93.2
Isla Negra	50 S	13	11.3	107.3	10.9	114.9	24.0	108.3	7.0	62.4
El Tabo		13	31.5	120.9	17.9	123.6	14.7	94.5	2.8	100.0

Sailing time (minutes) to fishing grounds located north or south from the harbor (El Quisco) and average number of days with favorable weather conditions for fishing operations are reported. Both were estimated on the basis of a survey conducted among fishermen. The percentage of trips made to each ground per year and CPUE are also reported.

The simplest abundance indicator used was catch per trip (hereafter, CPUE). The second abundance indicator uses hours at sea as effort (CPUEHours). The number of species caught per trip varied; divers collect not only crabs, but also other species (e.g., limpets, loco, sea urchins). The species diversity of the catches may be due to random opportunities during diving and/or sales opportunities (specific targets). Thus, several species may be caught per hour or trip, but only some of them can be considered target species. The remaining species can be considered bycatch (they represent a minimum proportion of the catch). Taking into consideration the way the fishery operates, a third indicator of abundance was estimated (CPUETarget) using the number of target species and hours at sea (crabs/[hours/number of target species]). This estimator assumes equal time allocation for each species targeted.

In order to determine what could be considered a target species, we classified the number of species caught into four categories: (1) other species was/were the target, and crabs were the bycatch; (2) crabs were the target, and all other species collected were the bycatch; and (3) two species were targeted (crabs plus another). We determined if a species was a target or bycatch based on our knowledge of ''minimum'' average potential catches by species, when that species is the target. Species were considered bycatch if the diver had collected: <15 kg of fish, <50 kg of tunicates (*Pyura chilensis*), <30 kg of limpets (*Fissurella* spp.), <100 sea urchins (*Loxechinus albus*), <30 kg of mussels (*Mytilus chilensis* and *Choromytilus chorus*). Species were considered target if (1) they dominated the catch (catch twice as high as the limit used to consider that species bycatch), and/or (2) for crabs, more than 50 crabs per trip were caught.

Two-way analyses of variance (ANOVAs) were used to test the effect of number of species caught (up to three) and time (years) on the different types of abundance indicators (CPUE, CPUEHours, and CPUETarget). Natural log transformations were used in CPUEHours, to correct for heterocedasticity. Multiple range tests (LSD approximation) were used for a posteriori comparison across means. The trend in catches and CPUE in Caleta El Quisco were examined on a monthly and annual basis. We identified the fishing grounds where the fishery operated between 1991 and 1994, analyzed trends in the exploitation of different fishing grounds, and discussed factors that could produce a differential use of effort in space.

The Effect of Fishing Gears

The Stone crab is mostly caught using two fishing gears: crab pots and divers, operating either from fishing boats or from the shore. Shellfish food gatherers that operate in the intertidal zone may also collect crabs (mostly unreported catches), but we have focused our study only on those fishing gears that account for most of the catches. Crab pots were introduced in Caletas El Quisco and Las Cruces as an alternative fishing gear in 1994.

Crabs landed in Caleta El Quisco (EQ, Fig. 1) and Caleta Las Cruces (LC, Fig. 1) between October 1994 and February 1995 were measured and sexed, in order to compare the catch composition (crab size and sex ratio) between two fishing gears (crab pots and divers). We report the proportion of ovigerous females, sexes, and undersized crabs.

Crab Size and Sex Ratio in Open Access Zones and MEAs

In April 1995, the El Quisco MEA (Fig. 1) was opened for a 1-day extraction. This event allowed us to study the effect of the Management and Exploitation Areas for Benthic Resources on the Stone crab population size structure and sex ratio.

During the ban lifting, there were 42 registered divers in El Quisco Union. Each fishermen had a quota for three species; the quota for the Stone crab was 50 crabs per diver. Eighteen divers extracted the quota (or part); catch per diver, crab size, and sex were recorded. We estimated CPUE in the El Quisco MEA. Several resources were extracted simultaneously, and when there were multiple targets, crabs were usually the bycatch. Thus, the comparison of CPUE (catch per trip) considering the effect of multispecies targets was not possible. However, in some cases, only crabs were harvested, and the CPUEDive (catch per unit of diving time) was estimated. No statistical comparisons between CPUEs in open access fishing grounds and MEA were conducted, because of the differences in the abundance indicators. The CPUEHours is expected to produce lower estimates, because sailing and han-

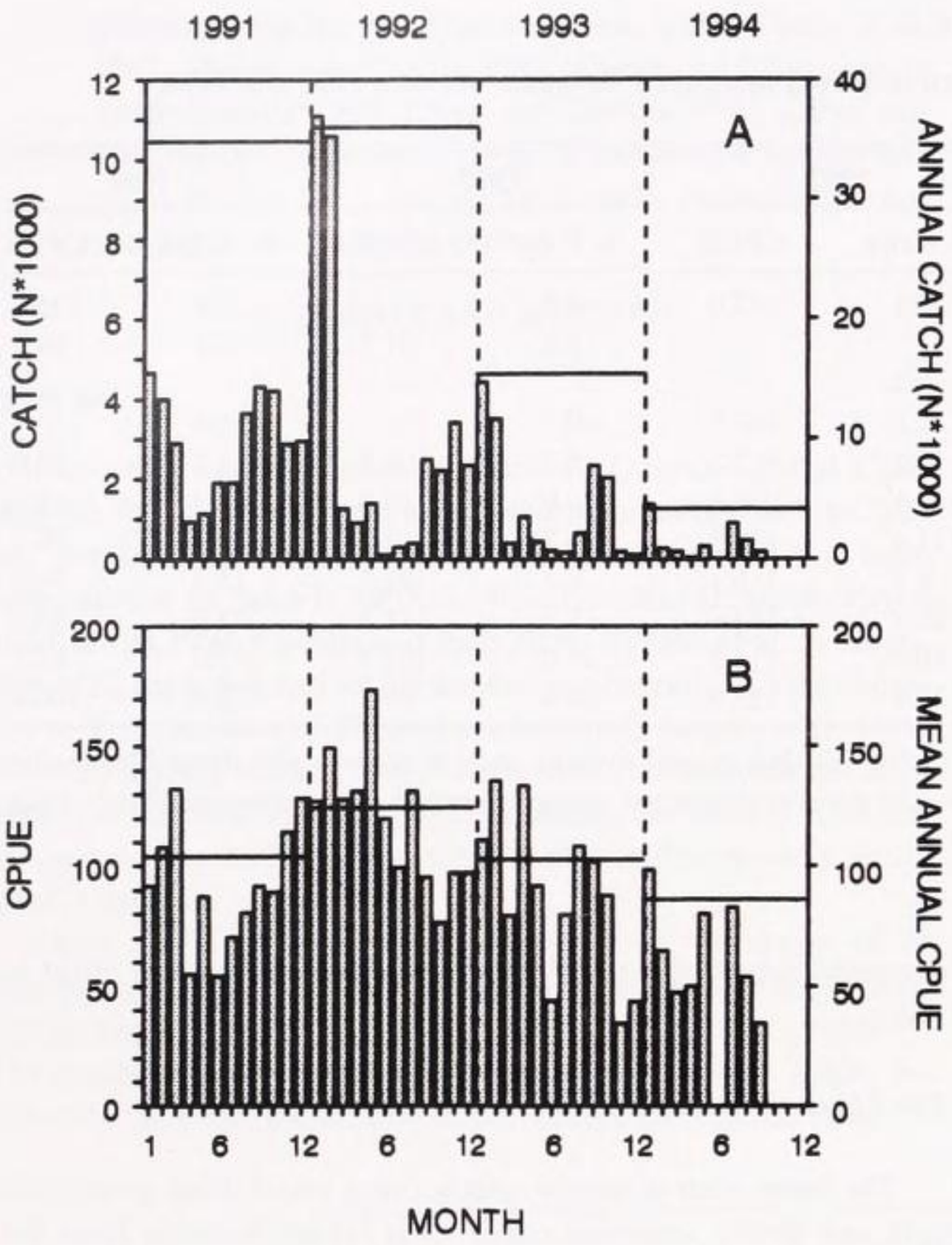

Figure 2. (A) Monthly crab catches (numbers) between 1991 and 1994 landed in El Quisco; horizontal lines (right *y*-axis) indicate total annual catch. (B) Monthly CPUE (catch in numbers per trip) between 1991 and 1994; horizontal lines (right *y*-axis) indicate mean annual CPUE. The CPUE was calculated by pooling the catches for different numbers of target species.

dling time were included, whereas only diving time was used for CPUEDive.

Crab size distribution, mean size by sex, and sex composition were compared between open access zones and the MEA of El Quisco. Only one fishing gear was compared (divers). Crabs were also measured in open access zones and in Las Cruces MEA (Fig. 1) between October 1994 and April 1995. In order to avoid confounding effects due to fishing gears, the most frequent fishing gear in Las Cruces (crab pots) was chosen for the comparison. Although depth may account for differences in sex ratio, it was not included in this analysis.

RESULTS

Exploratory Analysis of Alternative Abundance Indicators and Trends in Catches and CPUE Between 1991 and 1994

There was a sharp decline in total crab catches in Caleta El Quisco between 1991 and 1994. Annual catches were similar in 1991 and 1992 (35,416 and 36,526 crabs, respectively), but the monthly pattern differed (Fig. 2A). In 1991, the monthly distribution of the catches was more homogeneous than in 1992, when most of the activity occurred in January and February (Fig. 2A). In 1993, the annual catch decreased more than 50%, and a 10-fold decrease occurred between 1991 to 1992 and 1994. The price did not vary between 1991 and 1994. Although a decrease in the catches may have occurred, there was also a large proportion of unreported catches in 1994.

The annual CPUE also showed a declining trend, although the decrease between 1992 ($\bar{X}$ = 129.4) and 1994 ($\bar{X}$ = 82.6) was 36% (ANOVA: $F = 7.3$, $df = 3,668$, $p < 0.0001$; Fig. 2B). The number of species caught did not have any effect on CPUE (ANOVA: $F = 2.5$, $df = 2,668$, $p = 0.08$; Fig. 3A). The CPUE-Hours was also significantly different across years (ANOVA: $F = 9.8$, $df = 3,668$, $p < 0.00001$) and was affected by the number of species caught (ANOVA: $F = 13.3$, $df = 2,668$, $p < 0.00001$; Fig. 3B). The lowest CPUEHours corresponded to 1994 and 1991, and the highest corresponded to 1992 and 1993 (Fig. 3B). The CPUE-Hours was lowest when three species were caught, intermediate when two species were harvested, and highest when only crabs were caught. The CPUETarget was also significantly different across years (ANOVA: $F = 7.6$, $df = 3,668$, $p = 0.0009$; Fig. 3C). The highest estimates were found for 1992 and 1993, and the lowest were found for 1991 and 1994 ($p < 0.05$). The CPUETarget was not affected by the number of species caught ($F = 2.35$, $df = 2,668$, $p = 0.1$).

The CPUEHours was also compared across months for the 4 years. Although there were statistically significant differences within year, no clear, consistent pattern across years was found (Fig. 2B). In 1991, several homogeneous groups were detected; the highest CPUEHours were found between August and March, and

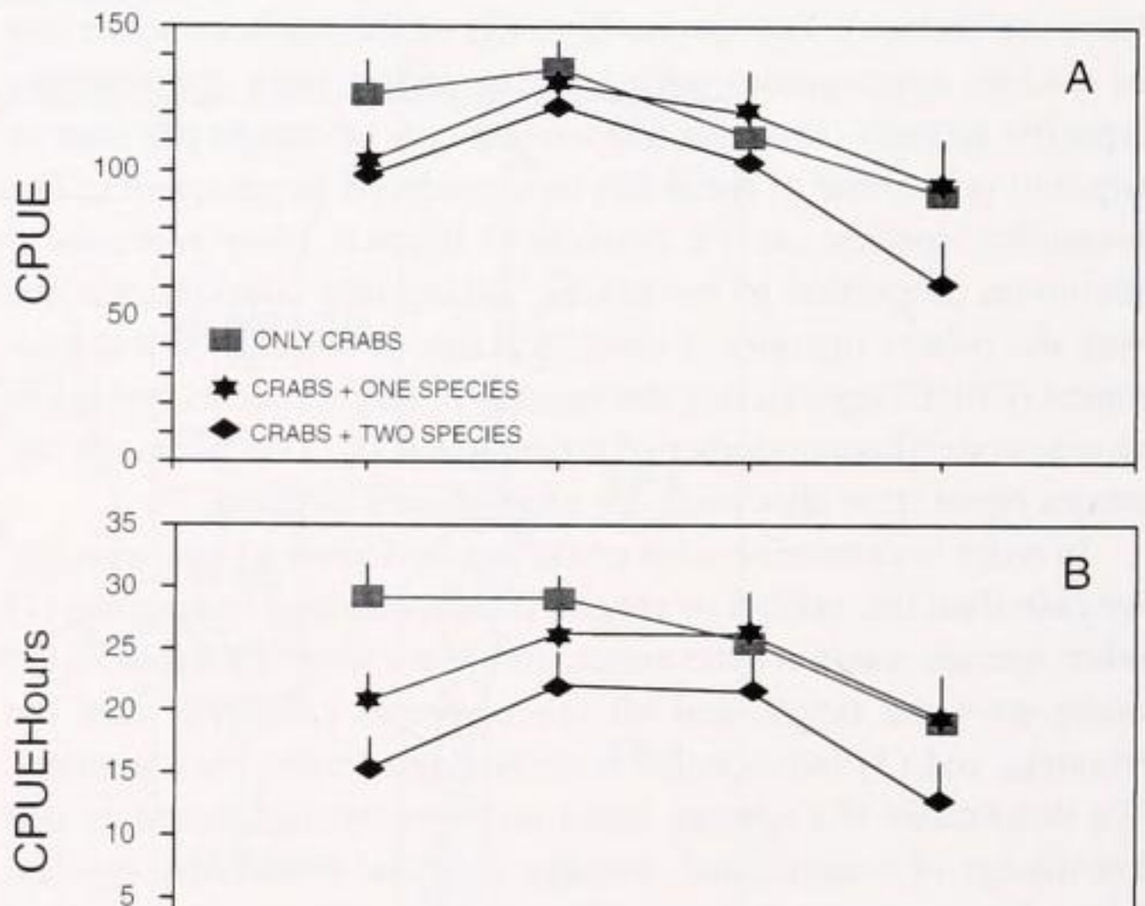

Figure 3. Abundance indicators estimated for El Quisco area combining all fishing grounds and divers between 1991 and 1994 when only crabs are the target species and when two and three species are targeted (including crabs). (A) CPUE (catch per trip); (B) CPUEHours (catch per hour at sea); (C) CPUETarget (catch per hour at sea corrected by the number of target species).

the lowest were found in the winter (June and July). Surveys conducted among fishermen of El Quisco showed that fishermen observed the lowest abundance of crabs in the winter. In 1992, the highest CPUEs were found between January and May, and the lowest were found between September and December. No clear patterns were found in 1993 and 1994.

The pattern of CPUE among fishing grounds was also explored. The rationale for this analysis was that fishing activities in the vicinity of the MEA may affect the abundance of mobile species in the closed areas. In 1991 and 1992, there was a tendency to exploit some fishing grounds located toward the south of the landing site (mostly Punta Tralca and El Tabo; Fig. 1 and Table 1), whereas in 1993 and 1994, the preference was not clear and fishing grounds located toward the north, or closer to the landing site (EQ), were also fished (Table 1). The fishing ground of El Gallo and Peña Blanca showed a low percentage of fishing trips, probably because of the low probabilities of favorable weather conditions (Table 1). The patterns of interest that appeared from this analysis were that: (1) the most productive fishing grounds (TQ, TL, TB; Table 1) are located toward the south, where the highest percentage of trips were reported; (2) multispecific targets were found in the most productive fishing grounds of Punta Tralca, Tablaque, and El Tabo; and (3) the three fishing grounds located closer to the marine reserve are mostly monospecifics, crabs being the main species harvested. A decrease in CPUE was observed in these fishing grounds in 1994 (Table 1). The three abundance indicators were also compared across years between the two most visited, and also very productive, fishing grounds: Punta Tralca and El Tabo. No differences were found in any of the comparisons (p always >0.05).

The Effect of Fishing Gears

Mean size, the proportion of undersized individuals in the catch, the sex ratio, and the proportion of ovigerous females were estimated for catches landed in Las Cruces and El Quisco between October 1994 and February 1995. In El Quisco, mean crab size ranged between 111.7 (standard deviation [SD] = 10.3, crab pots) and 112.9 (SD = 10.7, diver, ANOVA: $F = 0.4$, $df = 2{,}736$, $p = 0.69$), and only 25% of the catch was composed of legal-sized individuals (>110). The percentage of males caught in crab pots was higher (13%) than that caught by divers (4–6%), whereas the proportion of ovigerous females was lowest in crab pots (0.06%), intermediate for hooka-divers (8%), and highest for coastal divers (43%).

The main fishing gear identified in Las Cruces was crab pots; they can be deployed from a boat or by skin divers from the shore. Mean crab size was smaller when the crab pots were deployed by divers from the shore ($\bar{X} = 94.9$, SD = 9.7; ANOVA: $F = 158.6$, $df = 1{,}390$, $p < 0.00001$). Most of the catch was composed of undersized individuals (99%) and a high proportion of males (26%); no ovigerous females were caught. Mean crab size was larger for crab pots operated from a boat in the same fishing ground (108.2, SD = 10.9); 14% of the catch was composed of legal-sized individuals. The proportions of males (24%) and ovigerous females caught (0.09%) were similar to those found in the shallow subtidal crab pots.

Comparison in Catches and Size Between Open Access Zones and the MEAs

The size distributions of crabs collected by divers in open access zones and the MEA of El Quisco were not significantly different (KS: DN = 0.13, p = 0.198; Fig. 4A and B); females predominated in the MEA (90.6%) and open access zones (94%). The same pattern was observed in Las Cruces (KS: DN = 0.15, p = 0.18; Fig. 4C and D), although more males were present (between 17% in the MEA and 23% in open access zones). The size frequency distribution was also significantly different between El Quisco ($\bar{X} = 111.7$, SD = 10.29) and Las Cruces ($\bar{X} = 108.1$, SD = 10.9, KS: DN = 0.22, $p < 0.0001$). Crabs harvested with crab pots in both sites were used for the latter comparison.

During the one-time harvest of crabs, conducted in April 1995 in El Quisco, it was possible to estimate catch per hour of diving (CPUEDive). The average CPUEDive was 36.03 (crabs per hour when crabs were the only target, SD = 26.05) and varied between the subzones of the MEA. When two species were targeted, the CPUEDive was 42.5 (SD = 24.4), but the number of species targeted had no effect on the CPUEDive (ANOVA: $F = 0.27$, $df = 1.24$, $p = 0.61$).

DISCUSSION

The Stone crab represents an important resource for the Chilean artisanal fishery, comparable with the current landings (in tons) of limpets, locos, and some species of clams (SERNAP). On the basis of the data available at the national level, the Stone crab is the third most important crab species exploited in Chile, accounting for 13–16% of crab annual catches (SERNAP). The Stone crab is the

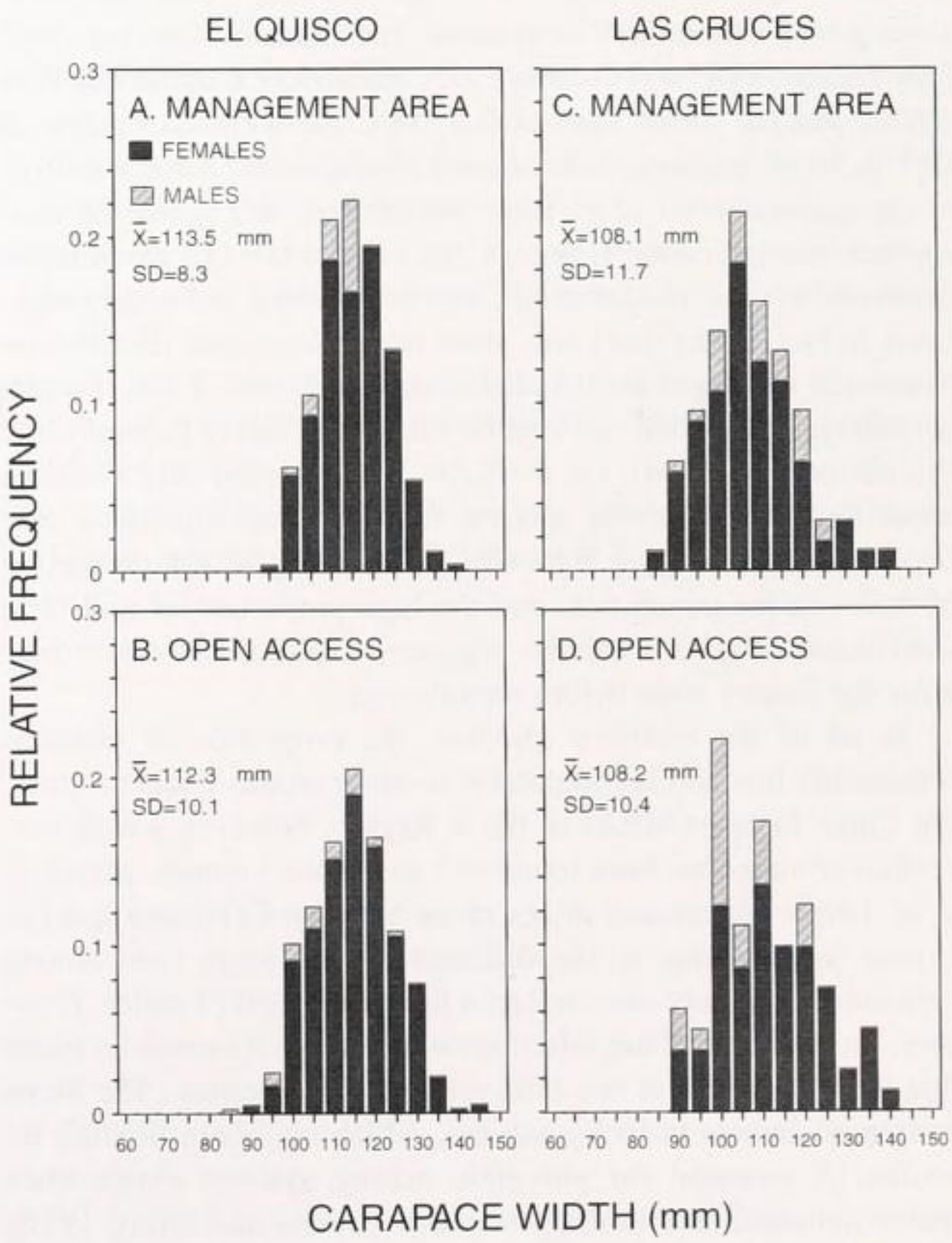

Figure 4. Size distribution by sex in two MEAs: (A) El Quisco and (C) Las Cruces and nearby open access fishing grounds; (B) El Quisco and (D) Las Cruces. In Las Cruces, only crab pots were used; in El Quisco, only crabs collected by divers were considered.

most important crab species harvested between the III and IV Regions and among the most important crab species in our study area (V Region). Annual catches of El Quisco represented 10% of the catches in the V Region in 1991 and 15% in 1992 and decreased to 7 and 3% in 1993 and 1994, respectively.

Between 1991 and 1994, there was a decrease in the percentage of Stone crab versus other crab species caught in the V region (SERNAP) and in El Quisco. On the basis of samples conducted in just one location in Central Chile (El Quisco), we could observe that the fishery statistics may show a dramatic underestimation of the current catch levels of the Stone crabs, as well as of other species. We compared the crab data that we collected between October 1994 and April 1995 with those recorded by the Fishermen Union, in order to estimate if the observed decreasing trend in catches was related to unreported cases. The proportion of unreported catches cannot be compared over time, but between October 1994 and April 1995, 85% of the crab catches were not reported and similar observations were made for other species. El Quisco is probably one of the locations where catch statistics are more reliable. A high proportion of unreported catches may not be exclusive to the Chilean artisanal fishery, but we think that it is important to emphasize that the actual crab catches may be much higher than official reports.

The main characteristic of the Chilean artisanal fishery is the diversification of fishing effort. Hooka-divers target on several benthic invertebrates, depending on fishing and sales opportunities. Despite the low capacity to improve the fishing efficiency in this artisanal fishery, and the diversification of effort among species, some species have been overexploited (e.g., loco, Castilla et al. in press), others showed dramatic reduction in size (e.g., keyhole limpets, Pino and Castilla 1995; sea urchin, Castilla and Pino 1996), and the Stone crab in Central Chile shows a decline in CPUE. Stock assessments have been conducted for some resources at the national level (e.g., loco, sea urchin), and quotas or bans applied in some cases. However, the current level of exploitation of several benthic resources in Chile is unknown and poorly regulated. In fact, in our study area, most of the Stone crab landings are composed of illegal-sized individuals (more than 75%). Similar percentages have been reported for other locations in Central Chile (Mendoza et al. 1994). On the basis of the limited data available about the biology of the species, females could reproduce only once before reaching the legal size. Considering the low proportion of males in the population, and the high proportion of undersize individuals caught, it can be suggested that some females may enter the fishery even before reproducing.

In all of the locations sampled, the proportion of males is remarkably low and is comparable to observations made in southern Chile. In other MEAs of the V Region, however, a high proportion of males has been found (1:1 to 2 male:1 female, Mendoza et al. 1994). Differences in sex ratios between El Quisco and Las Cruces may be due to the different fishing gears used among locations but, in any case, reflect a low proportion of males. However, on the basis of the information available, it cannot be stated that the differences in sex ratio are due to harvesting. The Stone crab uses shelters in rocky habitats, which may be a limiting resource. A potential for polyginic mating systems exists when males monopolize a limiting resource (Emlen and Oring 1977). Thus, the high proportion of females may also be explained by the mating system of this species. Carvacho et al. (1995) stated that a polyginic mating system in the Stone crab can be suggested by the early chelae development in males.

The estimation of abundance indicators for the Chilean artisanal fisheries has been challenged by the difficulties in obtaining reliable catch statistics, by the lack of effort data in most cases, and also by the multiple invertebrate species targeted (Bustamante and Castilla 1987). Here, we present alternative CPUEs that could be used for crab as well as for other benthic species. We show that the CPUEHours is affected by the number of species caught, which suggests the importance of taking this factor into account. The CPUETarget is not affected by the number of species caught (target and/or bycatch) because this estimator considers the time allocation for the main species collected. The latter may be a more appropriate indicator, because otherwise, the abundance indicator may underestimate the actual abundance, or show higher variability depending on the differences in number of species caught. It is worth noticing that the CPUETarget is higher when two or more species are collected. It may be because the most productive fishing grounds (highest CPUE) are multispecific, and time is optimized by harvesting several species than by searching for one specific target.

Although fishermen observation and CPUE trends indicate that, overall, the crab stock is declining, this tendency could not be observed at the fishing ground scale. The effect of harvesting on the most visited fishing ground could not be statistically detected on the basis of CPUE or CPUEHours until 1993. However, there was a trend to exploit more crabs near the MEA in 1993 and 1994, and in those specific fishing grounds, the CPUE decreased in 1994. This pattern of exploitation may have an effect on the crab abundance in the MEA, which does not show an increase in abundance as in sessile species. The CPUEDive estimated when crabs were the only target was comparable to that estimated in open fishing grounds (36.03 in the MEA, and from 17 to 29 in open fishing grounds). It should be noticed that the CPUE for the MEA was estimated using diving time as effort rather than total time (which includes diving, handling, and sailing times).

Size and sex ratio data collected in open fishing grounds are comparable to those recorded for the MEAs of El Quisco and Las Cruces. It is worth noticing, however, that the harvest strategy and the fishing gear in both locations are completely different. El Quisco MEA has been closed for the last 3 y, whereas Las Cruces MEA could be considered as an open access fishing ground. Thus, the effect of harvesting on crab size could not be observed, irrespective of the management strategies for the MEAs.

The lack of differences in crab size, sex ratio, and CPUE between open access fishing grounds and MEAs, and the lack of harvest effect at the fishing ground scale, suggest that the mobile characteristic of crabs may set new challenges to the new fishing strategy implemented by the Chilean Fisheries Administration. The use of MEAs was based on studies about the human effect on the intertidal community. Those studies, mostly directed toward sessile or relatively sedentary species, clearly showed the effect of human harvesting on species abundance and size (Castilla and Durán 1985, Durán and Castilla 1989, Durán et al. 1987, Castilla 1990, Oliva and Castilla 1990, Oliva and Castilla 1992). Recent studies conducted at El Quisco showed higher CPUE and size of sea urchins, keyhole limpets, and locos located in the MEA compared with the open access fishing ground (Pino and Castilla 1995, Castilla and Pino 1996, Castilla et al. in press). However, this pattern was not observed for crabs.

The underlying assumptions of the new Fisheries Law are that the MEAs can maintain juvenile and adult production of several species and contain enough adults to export larvae to surrounding

areas. Higher production of adult crabs has not occurred in El Quisco MEA. Furthermore, studies currently underway to examine habitat requirements of juvenile Stone crab have shown that El Quisco MEA ranked among the lowest in juvenile habitat quality, because extreme exposure to wave impact (M. Fernández unpublished). Thus, two of the underlying assumptions of the MEAs have not been met in our study area for the Stone crab.

Our analysis shows that Stone crab abundance is declining in the vicinity of El Quisco and that the MEA of El Quisco may not meet the restocking objective for this species. Despite the ambiguous perspective of the use of MEAs as a management strategy of mobile benthic resources, this study represents the first approach to address this issue. We think that the new comanagement tools implemented by the Chilean Fishery and Aquaculture Law may provide an opportunity to study the Stone crab population, not only contrasting the MEAs to open access zones, but also allowing for experimentation.

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LITERATURE CITED

Bustamante, R. & J. C. Castilla. 1987. The shell fisheries in Chile: an analysis of 26 years of landings. *Biologia Pesquera, Chile.* 16:79–97.

Carvacho, A., R. Tapia & C. Vidal. 1995. Aspectos reproductivos de la Jaiba Mora, *Homalaspis plana,* (Milne-Edwards, 1834) (Crustacea: Brachyura: Xanthidae) el seno de Reloncavi, Chile. *Biologia Pesquera.* 24:7–15.

Castilla, J. C. 1990. El erizo chileno *Loxechinus alba:* importancia pesquera, historia de vida, cultivo en laboratorio, y repoblacion natural. pp. 83–98. *In:* A. Hernández (ed.). Cultivo de moluscos en America Latina.

Castilla, J. C. & R. Bustamante. 1989. Human exclusion from intertidal rocky shores at Las Cruces, Central Chile: effects on *Durvillea antarctica* (Phaeophyta, Durvilleales). *Mar. Ecol. Prog. Ser.* 50:203–214.

Castilla, J. C. & L. Durán. 1985. Human exclusion from the rocky intertidal zone of Central Chile: the effects on *Concholepas concholepas* (Gastropoda). *Oikos.* 45:391–399.

Castilla, J. C., P. Manriquez, J. Alvarado, A. Rosson, C. Pino, C. Espoz, R. Soto, D. Oliva & O. Defeo. (In press.). The artisanal caletas as unit of production and basis for community-based management of benthic invertebrates in Chile. *Can. J. Fish. Aquat. Sci. (Sp. Publ.)*

Castilla, J. C. & C. Pino. 1996. The small-scale fishery of the red sea urchin, *Loxechinus albus,* in Chile and the Management and Exploitation Area of Caleta El Quisco. *Out of the Shell.* 5:5–8.

Durán, L. & J. C. Castilla. 1989. Variation and persistence of the middle rocky intertidal community of Central Chile, with and without human harvesting. *Mar. Biol.* 103:555–562.

Durán, L., J. C. Castilla & D. Oliva. 1987. Intensity of human predation on rocky shores at Las Cruces in Central Chile. *Environ. Conserv.* 14: 143–149.

Emlen, S. & L. Oring. 1977. Ecology, sexual selection and the evolution of mating systems. *Science.* 197:215–223.

Garth, J. 1957. The Crustacea Decapoda Brachyura of Chile. Reports Lund University Chile Expedition 1948–49. Vol. 20. *Lunds Univ. Arsskr. Avd. 2.* 53:1–127.

Henriquez, G. & N. Bahamonde. 1976. Clave de identificación y datos ecológicos de jaibas y pancoras frecuentes en las pescas comerciales de Chile. *Serie Investig. Pesq. IFOP.* 21:1–73.

Mendoza, O., J. Garrido & G. Jeréz. 1994. Investigación evaluación y manejo de recursos bentónicos IV Región. *Reporte Técnico IFOP.* 940.

Oliva, D. & J. C. Castilla. 1990. Repoblacion natural: el caso del loco *Concholepas concholepas* in Chile Central. pp. 273–294. In: A. Hernández (ed.). Cultivo de moluscos en America Latina.

Oliva, D. & J. C. Castilla. 1992. Programa REMA (Repopulation and Management): a pilot experiment in Central Chile. *Out of the Shell.* 2:16–17.

Payne, H. & J. C. Castilla. 1994. Socio-biological assessment of common property resource management: small-scale fishing Unions in Central Chile. *Out of the Shell.* 4:10–14.

Pino, C. & J. C. Castilla. 1995. The key-hole limpets (*Fisurella* spp.) in the Chilean artisanal fishery. *Out of the Shell.* 5:8–10.